



RAJASTHAN TECHNICAL UNIVERSITY KOTA
B. Tech. Petrochemical Engineering Syllabus
for
University Departments

B. TECH. III SEMESTER

MTL 204 Advanced Mathematics for Petrochemical Engineering

Laplace Transform: Definition and existence of Laplace transform, Properties of Laplace Transform and formulae, Unit Step function, Dirac Delta function, Heaviside function, Laplace transform of periodic functions. Finding inverse Laplace transform by different methods, convolution theorem. Evaluation of integrals by Laplace transform, solving ODEs by Laplace transforms method.

Fourier Transform: Fourier Complex, Sine and Cosine transform, properties and formulae, inverse Fourier transforms, Convolution theorem, application of Fourier transforms to partial ordinary differential equation (One dimensional heat and wave equations only).

Complex Variable-Differentiation: Differentiation, Cauchy-Riemann equations, analytic functions, harmonic functions, finding harmonic conjugate; elementary analytic functions (exponential, trigonometric, logarithm) and their properties.

Complex Variable-Integration: Contour integrals, Cauchy-Goursat theorem (without proof), Cauchy Integral formula (without proof), Liouville's theorem and Maximum-Modulus theorem (without proof); Taylor's series, zeros of analytic functions, singularities, Laurent's series; Residues, Cauchy Residue theorem (without proof). Evaluation of real integrals using residue theory.

Probability Theory: Basic concepts of probability, conditional probability, Baye's theorem. Random variable and distributions: Discrete and continuous random variables, Moments, Expectation, Moment generating function, Binomial, Poisson and Normal distribution

BOOKS:

1. Advanced Engineering Mathematics, Jain and Iyengar, Narosa Publications.
2. Advanced Engineering Mathematics, Irvin Kreyszig, Wiley, India.
3. Advanced Engineering Mathematics, M. Greenberg, Pearson Education, India.
4. Engineering Mathematics for semesters III and IV, C.B. Gupta, Mc Graw Hill Education, India.
5. Higher Engineering Mathematics, B. V. Ramana, Mc Graw Hill Education, India.
6. Spiegel; Laplace Transforms; Schaum's outline series.
7. Integral Transforms, Goyal and Goyal, Jaipur Publishing House, India.
8. B.S. Grewal, Higher Engineering Mathematics, Khanna Publishers, 35th Edition, 2010.
9. Introduction to Probability and Statistics, Seymour Lipschutz and John J. Schiller, Mc Graw Hill Education, India.
10. Fundamentals of mathematical statistics, S.C. Gupta and V.K. Kapoor, Sultan Chand & Sons., India.

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B. TECH. III SEMESTER

HUL202 Economics and Financial Management

PCL201 Chemical Process Calculations

Introduction: Unit Operations and Unit Processes and their industrial examples; Steady state and unsteady state processes; Batch, Continuous and Semi-batch Processes.

Units and Dimensions: Dimensions, Basic Units and Derived Units, Units Systems Conversion of units systems; Density and Specific gravity:API, Baume', Twaddell and Brix scale.

Basic Process Variables: Temperature, Pressure, Volume, Mass and Mole, Volume Fractions, Mass Fraction and Mole Fraction, Mass Flow Rate, Volume Flow Rate, Molar Flow Rate

Chemical Composition: Weight ratio, Mole ratio, Molality, Molarity, Normality, Wet basis and dry basis, Average molecular weight.

Behavior of gases: Ideal and Van der Waal Gases, Assumptions of Ideal gas, Ideal Gas Law and Van-der-Wall Equation, Gaseous Mixture, Specific volume of gas mixtures.

Material Balance: Law of Conservation of Mass, Overall and Component balances; Degree of Freedom, Degrees of Freedom analysis for given process unit; Material Balances and Calculations for Non-reacting Systems: Absorber, Stripper, Extraction, Distillation; Recycle, bypass and Purge calculations.

Stoichiometry: Introduction to Stoichiometry, Limiting Reactants, Excessive Reactant, Percentage Excess, Fractional conversion, Extent of reactions, Relation between fractional conversion and extent of reaction, Yield and selectivity, Balances and calculations for on reacting systems; Recycle, Bypass and Purge material balances and calculations involving chemical reaction.

Energy Balance: General energy balance equation for open systems and close system.Heat capacities of solid, liquid and gases; Sensible and Latent heat.Problems involving enthalpy change for gaseous and liquid streams.Energy balance for phase change in Condensation and Boiling;Balances on dissolution and heat of mixing processes.

Unsteady State Process Calculations: for a mixer, heating or cooling of a mixed liquid.

Heat of Reaction: Standard State, Heat of formation, Heat of combustion, Heat of reaction, Heat of mixing; Heat effects accompanying chemical reactions, Hess's Law, Kopp's law; Standard Heat of Reaction, combustion and formation. Effect of temperature on standard heat; Adiabatic Reaction Temperature, Theoretical Flame Temperature.

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BOOKS

1. K.V. Narayanan, B Lakshmikutty, Stoichiometry and Process Calculations, PHI learning Private Limited Delhi 2013
2. Himmelblau, D.M., "Basic Principles and Calculations in Chemical Engineering ", EESixth Edition, Prentice Hall Inc., 2003
3. Bhatt, B.L., Vora, S.M., "Stoichiometry ", 4th Edition, Tata McGraw-Hill (2004)
4. Felder, R. M. and Rousseau, R. W., "Elementary Principles of Chemical Processes", 3rdEdn. John Wiley & Sons, New York, 2000
5. Hougen O A, Watson K M and Ragatz R. A, "Chemical Process Principles" Part I, CBS publishers (1973).
6. McCabe, W.L., Smith, Julian C. & Harriett, Peter, "Unit Operations of ChemicalEngineering", McGraw Hill, New Delhi, 7/e, 2005

PCL202 Mechanical Operations

Particulate Solid: Properties of particulate solids Evaluation of size & shape, surface and population of particles, standard screens Particle size distribution. Mean particle size. Screen analysis of solids. Size measurement, Efficiency of separation and grade efficiency.

Size Reduction: Mechanism of size reduction. Energy for size reduction. Kics's law, Rittinger's law Screening, Methods of operating crushers. Nature of the material to becrushed. Type of crushing equipment. Coarse crushers. Intermediate crushers. Fine crushers. Specialized applications. Brief outline of particle size enlargement/reduction. Resistance to shear and tensile forces. Angles of repose and of friction.

Separation: :Theory of motion of particles through fluids, motion under gravitational and centrifugal fields, Terminal settling velocity of particles in a fluid (Stroke's law, Newton's law region and K-criteria for settling) Free settling and hindered settling. Gravity settling, centrifugal separation (cyclone separator) and sedimentation: Principles of sedimentation.

Mixing and Conveying: Transportation and Handling of Solids Selection of conveying devices for solids: Belt, Chain, Screw – conveyors, Elevators and pneumatic conveying devices; Elementary design aspects of the devices. Storage of solids-hoppers, silos. Agitation and mixing of fluids and solids, types of mixers, Standard design of mixing vessel **Types of Agitators:** axial flow impellers and radial flow impellers, Power number and Reynolds number for mixing, Power consumption of agitated vessels, Suspension of solids, the degree of mixing, Rate of mixing.

Filtration Theory. Relation between thickness of cake and volume of filtrate. Flow of liquid through the cloth. Flow of filtrate through the cloth and cake combined. Compressible filter cakes. Filtration Practice. The filter medium. Blocking filtration. Common Industrial filters

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BOOKS

1. Anup K Swain, Hemlata Patra, G. K. Roy Mechanical Operation, Tata McGraw Hill New Delhi
2. McCabe, W.L., Smith, Julian C. & Harriett, Peter, "Unit Operations of Chemical Engineering", McGraw Hill, New Delhi, 7/e, 2005.
3. Narayanan, C.M., Bhattacharya, B.C., "Mechanical Operations for Chemical Engineers", Khanna Publishers, Delhi. 3/e, 2005.
4. Brown G.G., "Unit Operations", John Wiley and Sons, New York, 1950

PCL203 Fluid Mechanics

Properties of fluids; Classification; Ideal fluid, Newtonian and Non-Newtonian fluids; Newton's law of viscosity. Pascal's and Hydrostatic law, manometers. Types of manometer

Fluid Statics: fluid pressure and its measurement. **Fluid Kinetics:** Continuity equation; types of flow.

Fluid dynamics: One dimensional equation of motion; Bernoulli's equation; application; application of Bernoulli's equation. Friction losses in pipe flow, valves and fittings, k-values, sudden expansion and contraction, pipe flow problems Nozzle. Introduction to laminar & turbulent flow. Velocity Distribution for turbulent flow, concept of Reynolds number & friction factor.

Flow through Pipes – Darcy – Weisbach's equation. Head loss in pipes. Pipes in series/ Parallel. Classification, basic construction and application of different types of pumps.

Pump: Centrifugal pump, Principles and application in Bernoulli's theorem Types of Pump: Axial pumps, Gear pump, Plunger Pumps Vane pump, Reciprocation pump and Screw pump. Characteristic Curves of Pumps. Valves, types of valves.

Flow Metering: Metering of fluids; orifice meter, Venturimeter, Pitot tube, Rotameter, Notches, Gas flow meters, coefficient of discharge.

BOOKS

1. McCabe, W.L., Smith, Julian C. & Harriett, Peter, "Unit Operations of Chemical Engineering", McGraw Hill, New Delhi, 7/e, 2005
2. Dr. P N Modi Dr. S M Seth Hydraulics and Fluid Mechanics - Standard Books House Engineering Fluid Mechanics, Kumar K.L., S Chand
3. R.K Bansal, Fluid Mechanics and Hydraulic Machine. S Chand

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B. TECH. III SEMESTER

PCL204 Introduction to Petroleum and Petrochemicals

Origin and Formation of Petroleum: Organic and Inorganic Theories, Reserves and deposits of Hydrocarbon in India, Indian Petroleum Industry, Benchmark crudes.

Composition of Crude Oils: Ultimate, chemical and bulk composition, Asphaltenes and Resins.

Classification of Crude Oils: Classification, Correlation Indexes: UOP characterization factor, BMCI.

Characterization of Crude Oils: Evaluation of crude oil, ASTM, TBP and EFV distillation curves.

Properties of Crude Oil: Physical & Thermal properties: Density, Specific gravity, Viscosity, Salt Content, Sulfur Content, Ash Content, Metal Content, Nitrogen Content, S&W etc.

Crude Oil Distillation Products and their quality control tests: Tests such as Viscosity, Octane Number, Cetane Number, sulfur content, Pour Point, cloud point, freezing point, Flash point, Fire Point, Smoke Point, Reid Vapor Pressure, Aniline Point, Carbon Residue.

Gaseous fuels: Composition & properties of Natural gas, Synthetic gases, Producer gas, Water gas, Coal Gas, LPG, CNG.

Introduction: Petrochemicals, Applications of Petrochemicals, History and growth of petrochemical industry in India, Petrochemical Industries in India.

Classification Petrochemicals: Based on processing stage, Number of carbon atoms; Petrochemicals from C₁, C₂, C₃, C₄, C₅, Syngas and Aromatics.

Petrochemical Feed Stock: Classification: Solid, Liquid, Gaseous

BOOKS

1. Bhaskar Rao, "Modern Petroleum Refining Processes", Oxford & IBH Co. Pvt. Ltd., New Delhi, 4/e, 2002,
2. M. Gopala Rao and Marshall Sittig, Outlines of Chemical Technology, 3/e, Affiliated East –West Press Pvt. Ltd, New Delhi
3. Speight, J.C.; "The Chemistry and Technology of Petroleum", Marcel Dekkar, New York, 3/e 1999.
4. Lucas, A.G. (ed.), "Modern Petroleum Technology", Vol. 2, Downstream, John Wiley & Sons Limited, New York, 6/e, 2000.
5. Prasad, R., "Petroleum Refining Technology", Khanna Publishers, New Delhi, 2000

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PRACTICALS

PCP201 Mechanical Operations Lab

1. To determine particle size distribution for a given sample. Using standard sieve series.
2. Experiment on blending of solid particles using a simple Fluid Mixing Apparatus
3. Experiment on the working of gas-solid cyclone separator.
4. Experiment on particle size reduction in Ball Mill.
5. Experiment on characteristics of fluidized beds.
6. Experiment on magnetic Separation
7. Study of the froth Flotation cell through magnetic separator
8. Experiment on agitation and mixing and filtration of rotator vacuum filter
9. Experiment on batch Sedimentation.
10. Experiment on leaf filter.

PCP202 Fluid Mechanics Lab

1. Reynolds experiment for Laminar, transitional and turbulent flow identification, through Reynolds apparatus
2. Verification of Bernoulli's Equation through Bernoulli's Theorem Apparatus.
3. Determination of coefficient of Discharge for Orifice, Venturimeter through venturimeter and orifice meter test rig.
4. Estimation of losses through pipe fitting, sudden enlargement and contraction frictional Pressure drop in Circular pipes.
5. Verification of Darcy's Law through Darcy apparatus.
6. To Study Construction, Working of Centrifugal, Reciprocating, Gear and Plunger Pumps through test rig
7. To Study Pitot tube apparatus and cavitation apparatus in a pipe flow.

PCP203 Data Base Management System for Chemical Engineers-Lab

Objectives: At the end of the semester, the students should have clearly understood and implemented the following:

1. Stating a database design & application problem.
2. Preparing ER diagram
3. Finding the data fields to be used in the database.

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4. Selecting fields for keys.
5. Normalizing the database including analysis of functional dependencies.
6. Installing and configuring the database server and the front end tools.
7. Designing database and writing applications for manipulation of data for a standalone and shared data base including concepts like concurrency control, transaction roll back, logging, report generation etc.
8. Get acquainted with SQL.

In order to achieve the above objectives, it is expected that each students will chose one problem. The implementation shall being with the statement of the objectives to be achieved, preparing ER diagram, designing of database, normalization and finally manipulation of the database including generation of reports, views etc. The problem may first be implemented for a standalone system to be used by a single user. All the above steps may then be followed for development of a database application to be used by multiple users in a client server environment with access control. The application shall NOT use web techniques. One exercise may be assigned on creation of table, manipulation of data and report generation using SQL.

Suggested Tools:

For standalone environment, Visual FoxPro or any similar database having both the database and manipulation language may be used.

For multi-user application, MYSql is suggested. However, any other database may also be used. For front end, VB.Net, Java, VB Script or any other convenient but currently used by industry may be chosen.

Indicative List of exercises:

1. Student information system for your college.
2. Student grievance registration and redressal system.
3. A video library management system for a shop.
4. Inventory management system for a hardware/ sanitary item shop.
5. Inventory management system for your college.
6. Guarantee management system for the equipments in your college.



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B. TECH. IV SEMESTER

CEL101 Environmental Science

HUL201 General Studies

PCL205 Heat Transfer

Conduction: Heat transfer modes, laws; General heat equation; Steady state problems in plane and composite systems; Thermal resistance; Insulation and critical radius; unsteady state heat conduction; Extended surfaces as Fins.

Convection: Principle Heat balance Equation in laminar flow; Natural convection heat transfer from plate and cylinder. Principles, Dimensional analysis of Heat Transfer by Forced, Principles, Dimensional analysis of Heat Transfer by Natural, Laminar and Turbulent Boundary layers; Laminar and turbulent flow heat transfer in a circular pipe. Dimensional groups in Heat Transfer

Condensation and Boiling: Types of condensation: Drop and Film condensation, Condensation on a vertical plate, vertical tube and horizontal tubes. Effect of superheated vapor and non-condensable gases. Types of boiling: Pool and forced boiling; boiling curves; Simplified relations for boiling heat transfer with water; Critical Flux.

Radiation: Basic concepts; Emission characteristics and laws of black body radiation; Radiation incident on a surface; Solid angle and radiation intensity. Heat exchange by radiation between two black surface elements; Heat exchange by radiation between two finite black surfaces; shape factor; Radiation shields.

Heat Exchangers Classification of heat exchangers; Overall heat transfer coefficient, fouling factor calculations; Analysis of Heat Exchangers: Logarithmic Mean temperature difference, Effectiveness – NTU Method.

Evaporator: Evaporators, types of evaporator method of feeding steam consumption, economy.

BOOKS

1. Holman, J. P., 'Heat Transfer', 8th Edn. McGraw Hill, 1997.
2. Kern, D.Q., "Process Heat Transfer", McGraw-Hill, 1999.
3. Coulson, J.M. and Richardson, J.F., "Chemical Engineering" Vol. I, 4th Edn. Asian Books Pvt. Ltd., India, 1998
4. McCabe, W.L., Smith, J.C., and Harriot, P., "Unit Operations in Chemical Engineering", 6th Edn. McGraw-Hill, 2001.

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B. TECH. IV SEMESTER

PCL206 Mass Transfer

Fundamentals of Mass Transfer: Individual and film coefficients, overall mass transfer Coefficient and their inter relationships; Analogies in transfer processes, determination of mass transfer coefficient.

Diffusion phenomenon: Molecular and eddy diffusion in gases, liquids and solids, Interface mass transfer. Mass transfer theories: film theory Penetration theory and surface renewal theory.

Humidification and Dehumidification: Humidification: General Theory, psychometric chart. Fundamental concepts in humidification & dehumidification, wet bulb temperature. Adiabatic saturation temperature, measurement of humidification calculation of humidification operation, cooling towers and related equipments.

Drying: Equilibrium mechanism theory of drying, drying rate curve. Batch and continuous drying for tray driers, Drum dryers, spray and tunnel dryers.

Absorption: Introduction to Adsorption, Absorption and Extraction in continuous contact columns; co-current, counter current and cross current contacting Absorption, calculations of NTU and HTU, Concept of HETP, Two phase flow in packed beds, co-current and counter current Processes Flooding loading, column internals: types of trays/ plates and packing, point and plate efficiency.

BOOKS

1. Binay. K. Dutta. Principles of Mass transfer and separation Process, PHI Learning Pvt Ltd.
2. Mc-Cabe W.L, Smith J.M.; Unit Operation in Chemical Engineering; Tat Mc-GrawHill.
3. Coulson J. M. Richardson; Chemical Engineering – Vol 2; Butserworth Heinmann, Oxford, Delhi
4. Treybal R.E; Mass Transfer Operatio; Mc. Graw Hill.
5. Sherwood, T.K. Pigford R.L. and Wilke, C.R.; Mass Transfer; Mc. Graw Hill.
6. Badger, W.L., Banchemo, J.T., “Introduction to Chemical Engineering”, McGraw-Hill Book Company.

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PCL207 Process Instrumentation

Introduction:-Introduction to chemical process instrumentation, Process variables, Static and dynamic characteristics of instruments; General classification of instruments, Principles, Construction and operation of Instruments for measurement. Elements of measuring systems & their functions.

Temperature measurement: Classification of thermometers and pyrometers, response of thermometers, protecting wells. Fluid filled expansion thermometers. Thermocouples: Resistance thermometers. Radiation and optical pyrometers.

Pressure and vacuum measurement: Classification, Manometers- Inverted well pressure gauges. Bourdon tube pressure gauges, diagram of pressure gauges. McLeod gauge. Classification of sensors and transducers.

Other Measurement Instruments: -Measurement of flow, Fluid level, pH, Conductivity, humidity and composition.

Process instrumentation diagram and symbols, process instrumentation for Process equipments such as distillation column, Heat exchanger, fluid storage vessel. Classification of sensors and transducers.

BOOKS:

1. Donal P Eckman-Industrial Instrumentation. Wiley 1995
2. Sarika Garg- Process Control and Instrumentation. BBP Publications Pvt. Ltd.
3. Albert D. Cooper- Modern Electronic Instrumentation, PHI
4. H.S. Kalsi- Electronic Instrumentation, Tata McGraw Hill, 2004.
5. Curties Johnson- Process Control Instrumentation Technique, IV Edn, PHI
6. Patranabis; Principles of Process Control; TMH

PCL208 Material Science and Technology

Introduction to materials: Atomic structure, bonding aggregates of atom. Crystals Structure: crystal structure, periodicity in crystal, types of structures: SC, BCC, FCC and HCP Crystals system, crystal lattice, unit cell, crystal direction, crystal planes, Miller indices, inter planar spacing, X-ray analysis, Crystals Defects: classifications and impact on the properties of engineering materials

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B. TECH. IV SEMESTER

Phase Equilibria – phase rule phase changes in pure Iron, binary systems, solid solution, Eutectic, Eutectoid, Peritectic and Peritectoid reactions. General principles of heat treatment: Annealing, normalizing, hardening, tempering and age hardening

Corrosion: Types of Corrosion in Industries, corrosion of materials in construction, pipe line and in equipments and its control

Materials and their properties:

Mechanical properties: Hardness, Strength, Toughness, Stiffness, Ductility, Malleability, Hardenability, Creep fatigue and Rheology.

Electrical properties: Conductors, Semiconductors and insulators, dielectric materials.

Optical properties: Absorption, Reflection, Transmission and Refraction, optical fibers and lasers.

Magnetic properties: various types of magnetic materials, Diamagnetic, Paramagnetic, Ferromagnetic, Ant ferromagnetic and Ferromagnetic materials, Domain theory, Hard and soft magnetic materials.

Thermal Properties: Thermal expansion, Heat capacity, Thermal Conduction, Thermal Stresses. Criteria for selection of materials for special applications in Industries such as smart materials. Smart materials

Characterization of Material: Principle, Construction and Procedure for characterization of material using Scanning Electron Microscopy (SEM), Transmission Electron Microscopy (TEM), EDS/EDX, Atomic force microscopy (AFM), Dielectric spectroscopy, Fluorescence spectroscopy.

Books

1. Material Science and Engineering by William Callister ·

PRACTICALS

PCP204 Mass Transfer Lab

1. To determine diffusion coefficient of solid vapour in air
2. To determine diffusion coefficient of Liquid vapour in air
3. To study the rate dissolution of a rotating cylinder and then to calculate the mass transfer coefficient. (Mass Transfer with and without chemical Reaction)
4. To investigate the mass transfer characteristic of a wetted surface column unit.

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5. To investigate the characteristics of cooling tower.
6. To study the drying characteristics of a wet granular material using natural and forced circulation in tray dryer.
7. To prepare the drying rate curve for force draft tray dryer.
8. To study the characteristics of spray dryer.
9. To study Absorption of gas in absorption column

PCP205 Heat Transfer Lab

1. To determine the thermal conductivity of Liquid.
2. To determine the equivalent thermal conductivity of composite wall.
3. To determine heat transfer coefficient in force convection and natural convection
4. Study of Unsteady state Heat Transfer Unit
5. To determine heat transfer coefficient with the help of Stefan Boltzmann Apparatus.
6. To calculate emissivity of the test plate by emissivity measurement apparatus.
7. To determine heat transfer coefficient in double pipe heat exchanger.
8. To study the heat transfer characteristics of a shell and tube heat exchanger.
9. To measure determine the heat transfer coefficient and heat transfer rate of film wise and drop wise condensation of pure water vapor.
10. To determine rate of evaporation through single effect evaporator.

PCP206 Process Instrumentation Lab

1. Study of temperature measuring instruments.
2. Study of pressure measuring instruments.
3. Study of flow measuring instruments.
4. Study of liquid level measuring instruments.
5. Study of composition measuring instruments.
6. Study of thermal conductivity measuring instruments.
7. Study of pH measuring instruments.
8. Study of transducers and sensors.

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B. TECH. V SEMESTER

HUL203 Indian Constitution

PCL301 Separation Process

Adsorption: Adsorption theories, types of adsorbent; activated carbon, silica and molecular sieves. Batch and column, adsorption; Break through curves, Liquid percolation and gas adsorption, Adsorption models for adsorption calculation.

Distillation: Vapour liquid Equilibrium, Boiling point diagram, Relative volatility, flash Distillation. Differential distillation for two component mixture, steam distillation, azeotropic distillation, Extractive distillation. Continuous and differential contact Distillation Rectification, reflux ratio, calculation of numbers of plates by NTU. Optimum reflux ratio, open steam, multiple feed and multiple product calculations, Enthalpy concentration diagram. McCabe Thiele and Ponchon-Savarit method for calculation of number of theoretical plates. Approximate equation; Fenske equation for minimum numbers of plate calculation. Batch distillation.

Liquid –Liquid extraction: Liquid equilibrium & Ponchon – Savarit method, McCabe- Thiele method, packed & spray column, Conjugate curve and tie line data, plait point, ternary liquid – liquid extraction. Operation and design of extraction towers analytical & graphical solution of single and multistage operation in extraction -Co-current, counter current and parallel current system

Leaching and Crystallization: Leaching: solid liquid equilibrium, Equipment, principles of leaching. cocurrent and counter current systems and calculation of number of stage required. Crystallization: Factors governing nucleation and crystal growth rates, controlled – growth of crystals, super saturation curve, principle and design of batch and continuous type equipment.

BOOKS:

1. Binay. K. Dutta. Principles of Mass transfer and separation Process, PHI Learning PVT Ltd.
2. McCabe, W.L. Smith J.M. – Unit Operations in Chemical Engineering – 5th edition TataMcGraw Hill – Hogakusha, Tokyo, New Delhi
3. Coulson J.M. Richardson J.F. - CHEMICAL ENGG. – Vol – 2 Edition-2, Butterworth Heinmann, Oxford, New Delhi.
4. Treybal R.E. – Mass Transfer Operation – 3rd edition, Mc. Graw Hill Book Co. New York

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B. TECH. V SEMESTER

PCL302 Chemical Reaction Engineering-I

Introduction: Importance of Chemical Reaction Engineering in an industrial Prospective, Mole Balance

Classification of reactions: Definition of reaction rate, Variables affecting the rate, concept of reaction equilibrium. Order of reaction and its determination, theoretical study of reaction rates, collision and activated complex theory. Mechanism of reaction series, Parallel and consecutive reaction, autocatalytic reactions, chain reaction, polymerization reaction

Interpretation of kinetic data: Integral and differential method of analysis, Variable volume reactions, total pressure method of kinetic analysis.

Classification of Reactors: Concept of Ideality, Industrial Reactor Batch Reactor, CSTR, PFR Development of design equations for batch, semi batch, tubular and stirred tank reactor .Design of Isothermal and non-isothermal batch, CSTR, PFR, reactors. Combination of reactors, Reactors with recycles.

Multiple Reactions: yield and selectivity in multiple reactions. Continuous stirred tank and Plug flow reactors uniqueness of steady state in continuous stirred tank reactor. Optimum temperature progression, thermal characteristics of reactors. Thiele modulus.

RTD and Models: RTD dispersion model, Tank and series model recycle model, segregated flow in mixed models. Residence time Distribution, evaluation of RTD characteristics.

BOOKS:

1. Fogler H.S; Elements Of Chemical Reaction Engineering; PHI
2. Smith J.M; Chemical Engineering Kinetics; Mc Graw Hill.
3. Denbigh & Turner K.G; Chemical Reaction Theory an Introduction; United Press.
4. Copper & Jeffery's G.V.J; Chemical Kinetics and Reactor Engineering; Prentice Hall
5. Levenspiel O; Chemical Reaction Engg; Willey Eastern, Singapore
6. Houghen Watson & Ragatz; Chemical Process Principles Part II; Asian Publication House Mumbai

PCL303 Applied Thermodynamics

Introduction and First law:The scope of thermodynamics, dimensions and units, measures of amount or size, force, temperature, pressure, work, energy and heat. The first law of thermodynamics and other basic concepts, Joules' experiment, internal energy. The first law of

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B. TECH. V SEMESTER

thermodynamics, energy balance for closed systems, thermodynamic state and state functions, equilibrium, the phase rule,

The reversible process, constant volume and constant pressure process, enthalpy, heat capacity.

The second law of thermodynamics statements of the second law, heat engines, thermodynamic temperature scales, entropy, entropy changes of an ideal gas, mathematical statement of the second law, entropy balance for open systems, calculation of ideal work, the third law of thermodynamics. Classification and performance of internal combustion engines.

Refrigeration and Liquefaction: the Carnot refrigerator-V and T-S diagrams. Analysis of air standard cycles. Carnot cycle, vapour –compression cycle, the choice of refrigerant, absorption refrigeration, the heat pump, liquefaction process.

Vapour- Liquid Equilibrium: The nature of equilibrium, the phase rule VLE – Quantitative behavior, VLE by modified Raoult’s Law, VLE from k-value correlations.

Solution thermodynamics: theory, fundamental property relation, the chemical potential and phase equilibria, partial properties. Ideal-gas mixtures, fugacity and fugacity coefficients, pure species, species in solution, generalized correlations for the fugacity coefficient, the ideal solution, excess properties. Application; liquid phase properties from VLE data, models for the excess Gibb’s energy, Property changes of mixing, heat effects of mixing processes

Chemical Reaction Equilibria: The reaction coordinate, application of equilibrium criteria to chemical reactions, the standard Gibbs. Energy change and the equilibrium constant, Effect of temperature on the equilibrium constants, relation of equilibrium constants to composition.

Equilibrium conversions for single reactions, phase rule and Duhem’s theorem for reacting systems.

BOOKS

1. Smith, J.M., Van Ness, H.C. and Abbott, M.M., “Chemical Engineering Thermodynamics”, Tata McGraw-Hill Publishing, New Delhi, 6/e, 2003.
2. Rao, Y.V.C. “Chemical Engineering Thermodynamics”, Universities Press, India 2/e, 2001.
3. Kyle; B.G., “Chemical and Process Thermodynamics”; Prentice Hall, New York, 3/e, 1999
4. K V Narayanan Chemical Engineering Thermodynamics, PHI Learning, 2004.

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B. TECH. V SEMESTER

PCL304 Chemical Technology

Chemistry and Technology:

Chemistry and technology for the production of following: Methanol, Formaldehyde, Vinyl Chloride, Ethylene oxide, Isopropanol, Cumene, Acrylonitrile, Isoprene, Ethylene glycol, Linear alkyl benzene, Phenol, Maleic anhydride, Phthalic anhydride, Styrene, Chlorobenzene, DMT, Terephthalic acid, Acrylic acid, Acetic anhydride, Acetone, Acetic acid.

Polymers:

Properties, applications and production technologies of the following engineering polymers: ABS plastic, Nylon-6, Polycarbonate, Epoxy resin, Unsaturated polyester resin, Rubber, Polystyrene, PVC, Polyethylene, LLDPE, HDPE, Polypropylene.

BOOKS

1. Waddams, A.L., 'Chemicals from Petroleum', 4th edition, Gulf Publishing Company, London, 1980.
2. M. Gopala Rao and Marshall Sitting, Outlines of Chemical Technology, 3/e, Affiliated East –West Press Pvt. Ltd, New Delhi
3. Lewis F. Hatch & S Matar, From Hydrocarbon to Petrochemicals, 2nd Edition, 2000, Gulf Publishing Co. Houston, Texas, USA.
4. Chauvel and B. Lefebvre, Petrochemical Processes 1 & 2; Gulf Publishing Co. Houston, Texas, USA.
5. B.K. Bhaskara Rao, A Text on Petrochemicals, 2/e, Khanna Publishers, Delhi, 1998.
6. Mall, I.D., "Petrochemical Process Technology", Macmillan India Limited, Delhi, 2007.
7. F.A. Lowenheim and M. K. Moran; Industrial Chemicals, John Wiley & Son Inc., USA

PCL305 Fluidization Engineering

Introduction: The phenomenon of fluidization; Advantages and disadvantages of fluidized beds; Industrial applications of fluidized beds The phenomenon of fluidization; Advantages and disadvantages of fluidized beds; Industrial applications of fluidized beds
Characteristics of solids: Classification of solids; Flow characteristics and its outline in the different types of fluidization.

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Flow pattern of fluidization system: Flow patter, flow pattern transition, flow pattern map, Frictional pressure drop and its model to analyze, Solid movement, mixing, segregation and staging

Flow pattern of fluidization system: Flow patter, flow pattern transition, flow pattern map, Frictional pressure drop and its model to analyze, Solid movement, mixing, segregation and staging

Gas distribution: Type of gas distributors in small and large scale industries, Design of distributor

Bubbling fluidized beds: Gas dispersion and gas interchange in bubbling beds, mixing characteristics: Entrainment and elutriation from fluidized beds

Attrition: Attrition mechanism and its analysis by model

Mass transfer phenomena: Particle to gas mass transfer phenomena and its analysis by model in two and three phase system and modeling

Heat Transfer phenomena: Heat transfer between fluidized beds and surfaces and modeling Design of fluidized bed reactors: Design for physical operation, catalytic and non-catalytic.

Books

1. D. Kunii (Author) Octave Levenspiel (Author) Fluidization Engineering Butterworth-Heinemann.

PRACTICALS

PCP301 Chemical Reaction Engineering Lab.

List of Experiment

1. Determine the rate constant and order of reaction in Batch reactor
2. To study temperature dependency of rate constant, evaluation of activation energy and
3. Verification of Arrhenius law in plug Flow Reactor
4. To study a parallel reaction system in cascade CSTR.
5. To study a homogeneous reaction in a semi-Batch reactor under isothermal conditions.
6. Study of non-catalytic homogeneous saponification reaction in CSTR.
7. To study a non-catalytic homogeneous reaction in a plug flow reactor.
8. To study the residence time distribution behavior of a Packed bed reactor.
9. To study the RTD behavior of a tubular reactor.
10. To study rate constant in Adiabatic batch Reactor.

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PCP302 Separation Process Lab.

List of Experiment

1. Studies on solid-liquid extraction column.
2. Study of the Swenson walker Crystallizer
3. To investigate the characteristics of cooling tower.
4. To study the drying characteristics of a wet granular material using natural and forced circulation in tray dryer
5. To study vapour Liquid equilibrium set up
6. Column for co-current and counter current flow of binary systems.

PCP303 Process Computation Lab

1. Introduction to Microsoft Excel for process calculation.
2. Basic operations using excel function.
3. Unit conversions of chemical process using excel.
4. Material balance solution using Excel.
5. Energy balance solution using Excel.
6. Calculation of multi variable equations.(i.e. gauss elimination method).
7. Problems related to Roults law and ideal gas equations on excel.
8. Introduction to chemical engineering software.
9. Problem solving with online available free software.
10. DWSIM software application.



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B. TECH. VI SEMESTER

PCL306 Chemical Reaction Engineering-II

Heterogeneous Processes: Catalysis and adsorption; Classification of catalysts, Preparation of catalysts, Promoters and Inhibitors. General mechanism of catalytic reactions surface area and pore size distribution Rate.

Catalyst Deactivation: Types of catalyst deactivation, kinetics of catalyst deactivation. Pseudo steady state hypothesis. Michaelis- Menten kinetics.

Design of Catalytic Reactors: Steady State Non Isothermal reactor Design, energy Balance, Non Isothermal Continuous Flow reactor, Non Adiabatic Reactor Operation, Adiabatic tubular reactor. Isothermal and non-isothermal effectiveness factors.

Kinetics of Fluid Particle Reaction:- Progressive Conversion models, Shrinking Core Models, Models for fluid - solid non-catalytic reactions, controlling mechanisms, Diffusion through gas film controls. Diffusion through ash layer controls, Chemical reaction controls. Global reaction rate.

Multiphase Reactor: Fluidized bed reactors, Slurry reactors, Trickle bed reactors and its applications. Fluidized bed reactors with and without elutriation. Gas Liquid reaction on solid Catalyst.

BOOKS:

1. Fogler H.S; Elements Of Chemical Reaction Engineering; PHI
2. Smith J.M; Chemical Engineering Kinetics; Mc Graw Hill.
3. Denbigh & Turner K.G; Chemical Reaction Theory an Introduction; United Press.
4. Copper & Jeffery's G.V.J; Chemical Kinetics and Reactor Engineering; Prentice Hall
5. Levenspiel O; Chemical Reaction Engg; Willey Eastern, Singapore
6. Houghen Watson & Ragatz; Chemical Process Principles Part II; Asian Publication House Mumbai

PCL307 Process Modeling & Simulation

The role of analysis:

Chemical engineering problems, basic concepts of analysis; the analysis process, simple example of estimating an order, source of the model equations. Conservation equations, constitutive equations, control volumes, dimensional analysis, system of units, dimensional consistency in

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mathematical descriptions, dimensional analysis and Constitutive relationships, final observations.

Non-Reacting Liquid Systems:

Introduction, equation of continuity, simple mass balance, application of the model equations, component mass balances.

Model behavior:

Steady state behavior, un-steady state behavior, density assumption, numerical integration methods of ordinary differential equation.

Reacting Liquid Systems:

Introduction, basic model equations for a tank-type reactor, reaction rate, batch reactor, pseudo first-order reactions, reversible reactions, multiple reactions. Consecutive reactions, parallel reactions, complex reactions, constant density assumption, order and stoichiometry.

Treatment of experimental data:

Introduction, criteria for Best Fit, Best Slope-I, Best straight line. Fitting a quadratic, simulation examples of gravity fluid flow, heat and mass transfer. Dynamic modelling of simple processes, sequential, simultaneous modular and equation oriented approaches.

Computer programming of various iterative convergence methods such as Newton- Raphson, false position, Muller methods.

BOOKS:

1. Russell TWF; Introduction to Chemical Engineering Analysis - John Wiley & Sons
2. Luyben W.L; Process Modelling, Simulation and Control for Chemical Engineers; TMH
3. Jana; Chemical Process Modelling and Computer Simulation; PHI Learning

PCL308 Process Equipment Design

Heat Exchanger Design:

Introduction: Heat Exchanger, Classification and Application of heat exchanger, Heat exchanger analysis, Overall heat transfer coefficient, Fouling factor, Heat exchanger design procedure, Heat-exchanger standards and codes, General design considerations for heat

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exchangers, Shell and Tube heat exchanger, Components of Shell & Tube heat exchanger, Types of Shell & Tube heat exchangers . **Design Calculations:** Tube: Dimensions, Tube arrangements, Tube-side passes; Shell: Dimensions, Shell passes; Baffles: Types; Support plates and tie rods, Tube sheets, Tube-sheet layout, Shell and header nozzles, Flow-induced tube vibrations, Mean Temperature Difference, Tube side calculations: Heat transfer coefficients and pressure drop; Shell side calculations: Heat transfer coefficients and pressure by Kern's & Bell's Methods.

Condensers Design:

Introduction: Condensation, Film-wise and dropwise condensation, Types of condensers: Vertical condenser and Horizontal condenser, De-superheating and sub-cooling. **Design Calculations:** Mean temperature difference, Tube side calculations: Heat transfer coefficients and pressure drop; Shell side calculations: Heat transfer coefficients and pressure.

Reboiler Design:

Introduction: Boiling, Pool boiling, Convection boiling, Reboiler, Classification of reboilers
Design of kettle reboiler: Design considerations, Individual heat transfer co-efficient hot fluid and boiling liquid, allowable vapor velocity, Tube side and shell side pressure drop.

BOOKS:

1. R. K. Sinnott, Coulson & Richardson's Chemical Engineering: Chemical Engineering Design (volume 6), Butterworth-Heinemann, 3rd ed. 1999.
2. Indian Standard (IS: 4503-1967): Specification for Shell and Tube Type Heat Exchangers, BIS 2007, New Delhi.
3. D. Q. Kern, Process Heat Transfer, McGraw-Hill Book Company, Int. ed. 1965.
4. Standards of the Tubular Exchanger Manufacturers Association (TEMA), Inc. 18 ed., 1999, New York.
5. Ludwig E; Applied process design in chemical petrochemical plants; Gulf publishing co.

PCL309 Health Safety & Environment

Importance of Safety

Industrial safety and loss trends, safety and environmental concerns, development of industrial safety and loss prevention approaches – loss prevention. Total loss control, quality assurance,



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B. TECH. VI SEMESTER

total quality management, concept of hazard system. The characterization of hazards, hazard sources and their realization, IS Codes used for safety.

Safety Hazards

Major process hazards: self-heating, flame propagation, limits of flammability, explosion, detonation and deflagration, toxic materials. Dosage, acute and chronic effects, threshold limits, fire, explosion and toxic release, effects of hazards.

Building a Safe Environment

Parameters determining probability and consequence of hazards, occupational health and hygiene, personal safety methods, work permit, material safety data sheet.

Hazard identification: use of hazard indices, hazard and operability studies

Hazard Control: Major hazard control, legislation and laws, case studies of major hazardevents.

Impact on Air

Air pollution: major pollutants, meteorology, lapse rate, dispersion, engineering control of air pollution. Safety aspects of H₂S leakage from oil and gas fields. Air pollution causes, remedies in fertilizer plants, petrochemical plants etc.

Impact on Water

Water pollution: physical, chemical and biological water quality parameters, pollution by oil spills. Ground water pollution near oil dispensing stations.

Pollution Control

Remediation of the environment, engineered systems for water purification, sludge treatment and disposal. Water pollution causes and remedies in oil production sites, refiners and in production of petrochemicals,

HSE laws, regulations and norms in respect of petroleum industry

BOOKS:

1. Daniel A. Crown chemical Process Safety Fundamental with Application Prentice Hall International Series

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2. Loss Prevention in the Process Industries, Less, F. P., 2nd ed. Butterworth Heinemann, UK,
3. Environmental Engineering; Peavy, H. S., Rowe, D. R. and Tchobanoglous, G., McGraw Hill.
4. Chemical Process Safety, Sanders, R. E., Butterworth Heinemann, UK
5. Critical Aspects of Safety and Loss Prevention, Kletz, T. A., Butterworth Heinemann, UK.
6. Stefan Orszulik Environmental Technology in Oil Industry – Springer.

PCL310 Petroleum Refinery Engineering

Separation Processes: Atmospheric Distillation, Vacuum Distillation.

Cracking Process:

Thermal conversion processes. Conventional thermal cracking process. Visbreaking, Coking – Fluid coking, flexicoking, delayed coking etc.

Reforming:

Catalytic conversion processes – fluid catalytic cracking, Hydrocracking, hydrogen production, Reforming.

Purification process

Alkylation, Polymerization process of crude oil. Isomerisation and Hydrotreating processes crude oil.

Crude oil Evaluation: Evaluation of crude oil for LOBS (Lube oil base Stock). Steps in preparation of LOBS, deasphalting.

Solvent Extraction: Types of solvents available and their comparison, dewaxing. Hydro finishing of LOBS Hydrogenation processes for LOBS production.

Text Books

1. Petroleum Refining Technology and Economics', James H. Gary. and Glenn E. H. 4 ed., Marcel Dekker, Inc., 2001 CRC
2. Petroleum Refinery Engineering, Nelson N.L., McGraw Hill Book Co., 1985
3. Petroleum Refining, Waquier, J.P., Vol .I and II, 2 ed., Technip, 1995
4. Petroleum Processing Handbook, Mcketta S.S., Marcel Dekker, Inc., 1992

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B. TECH. VI SEMESTER

PCL311 Biomass Conversion

Introduction: World energy scenario, consumption pattern, fossil fuel depletion and environmental issues

Biomass: Availability and abundance, photosynthesis, composition and energy potential, virgin biomass production and selection, waste biomass (municipal, industrial, agricultural and forestry) availability, abundance and potential, biomass as energy resources: dedicated energy crops, annual crops (maize, sorghum sugar beet, hemp), perennial herbaceous crops (sugarcane, switchgrass, miscanthus), short rotation woody crops (poplar, willow), oil crops and their biorefinery potential, microalgae as feedstock for biofuels and biochemical, enhancing biomass properties for biofuels, challenges in conversion

Biorefinery: Basic concept, types of biorefineries, biorefinery feedstocks and properties, economics

Biomass Pretreatment: Barriers in lignocellulosic biomass conversion, pretreatment technologies such as acid, alkali, autohydrolysis, hybrid methods, role of pretreatment in the biorefinery concept

Physical and Thermal Conversion Processes: Types, fundamentals, equipments and applications; thermal conversion products, commercial success stories

Biodiesel Diesel from vegetable oils, microalgae and syngas; transesterification; FT process, catalysts; biodiesel purification, fuel properties

Bioethanol and Biobutanol: Corn ethanol, lignocellulosic ethanol, microorganisms for fermentation, current industrial ethanol production technology, cellulases and their role in hydrolysis, concepts of SSF and CBP, advanced fermentation technologies, ABE fermentation pathway and kinetics, product recovery technologies

Hydrogen, Methane and Methanol: Biohydrogen generation, metabolic basics, feedstocks, dark fermentation by strict anaerobes, facultative anaerobes, thermophilic microorganisms, integration of biohydrogen with fuel cell; fundamentals of biogas technology, fermenter designs, biogas purification, methanol production and utilization

Books

1. Donald L. Klass, Biomass for Renewable Energy, Fuels, and Chemicals, Academic Press, Elsevier, 2006.

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2. Prabir Basu, Biomass Gasification, Pyrolysis and Torrefaction, Academic Press, Elsevier, 2013.
3. A.A. Vertes, N. Qureshi, H.P. Blaschek, H. Yukawa (Eds.), Biomass to Biofuels: Strategies for Global Industries, Wiley, 2010.
4. S. Yang, H.A. El-Enshasy, N. Thongchul (Eds.), Bioprocessing Technologies in Bio refinery for Sustainable Production of Fuels, Chemicals and Polymers, Wiley, 2013.
5. Shang-Tian Yang (Ed.), Bioprocessing for Value Added Products from Renewable Resources, Elsevier, 2007.

PRACTICALS

PCP304 Process Modeling Simulation Lab

1. Simulation of gravity flow tank by Euler Method
2. Simulation of gravity flow tank by Range Kutta Method
3. Simulation of three CSTR in series by Range Kutta method
4. Simulation of three CSTR in series by Euler method
5. Simulation of three CSTR in series with feedback -loop by Euler method
6. Modelling a batch reactor-verification of 1st and 2nd order rate kinetics.
7. Counter current double pipe heat exchanger modeling-data analysis by iterative methods
8. Simulation of a distillation column-binary systems, equi-molal overflow, constant relative, volatility.

PCP305 Health Safety & Environment Lab.

List of Experiments

1. To determine the pH value of a given water Sample.
2. To determine the DO of a given water Sample.
3. To determine the COD of a given water Sample.
4. To determine the Chlorides in a given water Sample.
5. To determine the Fluoride content of a given water Sample

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6. To determine the Acidity in a given water Sample.
7. To determine the Alkalinity in a given water Sample.
8. To determine the Total Hardness in a given water Sample.
9. To determine the Turbidity of a given water Sample.
10. To determine Total dissolved solids of a given water sample

PCP306 Petroleum Product Testing Lab

1. Measurement of fire point- Flash point
2. Measurement of Cloud point and pour point.
3. Measurement of Aniline point & Bromine number
4. Measurement of Reid Vapour Pressure
5. Measurement of Sulphur Content
6. Measurement of Carbon Residue.
7. ASTM Distillation of Petroleum products.
8. Measurement of surface tension by Tensiometer.
9. Measurement of surface tension by Platinum ring method.
10. Determination of smoke point.



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B. TECH. VII SEMESTER

PCL401 Plant Design & Economics

Introduction: Process Design development, General design considerations, Cost and asset accounting,

Cash flow for industrial operations, factors effecting investment and production cost, capital investments, estimation of capital investments, cost indices, cost factors in capital investment.

Organizations for presenting capital investments, estimates by compartmentalization, estimation of total product of cost direction, production costs, fixed charges, plant overhead costs, financing.

Interest and investment cost, type interest, nominal and effective interest rates, continuous interest, present worth and discount annuities, cost due interest on investment, source of capital.

Taxes and insurances: type of taxes: federal income taxes, Insurance-types of insurance, self-insurance.

Depreciation: types of depreciation, services life, salvage value, present value, Methods for determining depreciation, single unit and group depreciation.

Profitability: alternative investments and replacements, profitability standards, discounted cash flow

Capitalized cost, pay out period, alternative investments, analysis with small investments, increments and replacements.

BOOKS:

1. Max S. Peters, Klaus D. Timmerhaus and Ronal E. West, Plant Design and Economics for Chemical Engineers, 5th ed. (2002), McGraw-Hill, New York
2. Schwever , H.D., “Process Engineering Economics”, McGraw- Hill.
3. Chilton, “Chemical Engineering Cost Estimation”, McGraw-Hill.
4. Bauman, H.C., “Fundamentals of Cost Engineering in the Chemical Industry”, Reinhold Book Corporation, New York.
5. Jelen, F.C., “Cost and Optimization Engineering”, Mc Graw-Hill, New York.

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RAJASTHAN TECHNICAL UNIVERSITY KOTA
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B. TECH. VII SEMESTER

PCL402 Process Dynamics & Control

First-order Systems: Introduction, Transfer Function, Linear Open-Loop Systems, Transient response (step response, impulse response, and sinusoidal response), response of first order systems in series. Non-interacting systems and interacting systems.

Second-order systems: Transfer function, step response, impulse response, k sinusoidal response, transportation lag.

Linear closed-loop Systems: Control System: components of a control system block diagram. Negative feedback and positive feedback, servo problem and regulator problem.

Closed-Loop Transfer functions: Overall transfer function for single loop systems, overall transfer function for set-point change and load change, multi-loop control systems. Transient Response of simple control systems: P and PI control for set point change and for load change.

Controller and final control element: Mechanism of control valve and controller, transfer functions of control valve and controllers (P, PI, PD, and PID). Examples of a chemical reactor control system. **Stability:** Concept of Stability, Stability criteria, Routh test for stability, Root Locus.

Frequency Response: Introduction to Frequency Response, Bode Diagrams for First and second order systems, Bode stability Criteria, Ziegler-Nichols and Cohen-coon Tuning rules.

BOOKS:

1. Process Systems Analysis and control, Coughanowr, D.R., McGraw –Hill, 1991.
2. Chemical Process Control, Stephanopoulos, G, PHI,
3. Process Instrumentation R.P.Vyas Dinut publication.
4. Process Modelling, Simulation and Control for Chemical Engineers, Luyben, W.L, McGraw Hill,
5. Process Control Principles and Application, Surekha Bhanot, Oxford Higher Education/Oxford University Press, 2008
6. Process Control, Peter Harriott, Tata McGraw-Hill Publishing Company, 1964

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B. TECH. VII SEMESTER

PCL403 Transport Phenomenon

Similarity in momentum, heat and mass-transport - Newton's laws of viscosity.

Fourier's laws of conduction and Fick's laws of diffusion, Flux-transport property relationships.

Estimation of transport properties measurement and correlations, velocity distribution in Laminar flow of falling film.

Flow over an inclined plane, a circular tube an annulus and between two parallel plates.

Shell balance approach for developing equations of change for momentum, heat and mass transport.

Shell balance approach for developing equations of change for momentum, heat and mass transport.

Transport equations in turbulent flow and equations for turbulent fluxes. Velocity, Temperature and concentration profiles for laminar and turbulent flow conditions.

Temperature and concentration profiles for conductive and convective transport in solids and fluids.

Macroscopic momentum and heat balance equations, Kinetic energy calculations, Constant area and variable area flow problems.

Flow through bends, time determination for emptying of vessels.

BOOKS:

1. Bird R.B., Stewart W.E. and Lightfoot EW; Transport phenomena; Wiley tappon
2. Brodkey RS and Hershey -Transport phenomena a unified approach; TMH
3. Geancoplis; Transport processes & separation process principles; PHI learning.

PCL404 Polymer Science and Technology

Classification of Polymers:

Linear branched and cross-linked polymers, Molecular weights of polymers. Polydispersity and Mol. Wt. distribution in polymers. Random, alternate, block and graft co-polymers,

Polymer Characterization Techniques:

Composition, Molar Mass and Molar Mass Distribution; Structure and Morphology; Molecular Organization and Dynamics;

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B. TECH. VII SEMESTER

Polymerization:

Kinetics of chain & Step polymerization, techniques of molecular weight control. Initiators, Chain transfer agents, Inhibitors. Techniques of polymerization. Bulk, Solution, Suspension & Emulsion polymerization

Introduction to Polymer Rheology:

Newton's law of viscosity, viscometris plots, rheometers. Rheological models, theory of viscoelasticity, Heat distortion temperature.

Polymer Processing:

Compounding methods, Extrusion moulding, Injection moulding. Blow moulding, Rotational moulding. Introduction to fibre reinforced plastics.

BOOKS:

1. Kumar, A., "Fundamentals of Polymer Engineering", 2/e, Marcel Dekker, New York, 2003
2. Gowariker, V.R., Viswanathan, N.V. and Sreedhar, J., "Polymer Science", New Age International (P) Ltd, New Delhi, 1986.
3. Odian, G., "Principles of Polymerization", John Wiley & Sons Inc, New York, 1991.
4. Tager, A., "Physical Chemistry of Polymers", Mir Publishers, Moscow, 1978.

PCL405 Refinery Engineering Design

Overview of Refinery:

Global and Indian Refining Industry, Refinery configurations, ASTM Distillation TBP Distillation, EFV distillation. Analysis of crude petroleum and its fractions. Different types of Boiling point, VABP, WABP, MABP, MeBP, CABP Computation of the curves, Calculation of ASTM temperature to TBP and EFV temperature, Average boiling points, Separation criteria in crude oil fractionation. Calculation for characterizing crude oil.

Atmospheric distillation unit:

Atmospheric distillation tower, types of refluxes, pump around reflux pump back reflux top tray reflux, converting crude TBP to product TBP curves, concept of overflash. Energy balance in a topping tower and calculations involve estimation of top, side, bottom draw tray temperatures. Calculation of side steam strippers.

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B. TECH. VII SEMESTER

Vacuum distillation Unit

Vacuum distillation tower, type of operations, Lube type Vacuum tower with pump back and pump around reflux heat removal. Lube or special vacuum distillation operation economic consideration in Vacuum Tower.

Fired Heater:

Types of fired heaters, Horizontal Types, Vertical Types, Codes and standards Burner, Gas burner Oil burner combination burners. Preparing refractories for operation stacks emissions, Basic constructional features of furnace, Different furnace types.

BOOKS:

1. R.N. Watkin, Petroleum Refinery Distillation, 2/e Gulf Publishing Co, Houston, Texas, USA, 1981.
2. B.K Bhaskar Rao, Modern Petroleum Refining Processes, 3/e, Oxford & IBH Publishing Co Pvt. Ltd., 1997.
3. Sinnott R. K., "Coulson and Richardson's Chemical engineering", Vol. 6, Third Edition, Butter Worth-Heinemann, 1999.
4. Kern D. Q., "Process Heat Transfer", McGraw Hill, 1965

PCL406 Pipeline Engineering

Objective and scope of pipeline: As a means of fluid transportation with special reference to crude oil/gas/refined products.

Design of Pipeline: Factors influencing oil, gas and refined products as pipeline design; Hydraulic surge and water hammer; specific heat of liquids, river crossing; pipe size and station spacing etc.

Theory and different formulae of the flow of fluids :Basic equations for the flow of fluids through pipes; different flow equations for laminar and turbulent flow of compressible and incompressible fluids, Introduction to the flow of Non- Newtonian fluids through pipes, multiphase flow and loop pipelines.

Construction of pipelines: materials; project specifications, general equipment specifications (Pipes, valves and fittings), Installation of expansion loops and thermodynamic tapping plant.

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B. TECH. VII SEMESTER

Pigging: Pigging technology, pig launcher and receiver, intelligent pigging, types of pigs.

Offshore Pipeline: design and control of Sag and Over bend; description of stinger and riser, articulated stinger, construction of offshore pipeline; method of underwater welding Prevention of hydrates, wax & scales. Crude conditioning and use of additives to improve flow conditions.

Corrosion: protection and control; design of cathodic protection system, pipeline automation. City distribution network of oil/gas.

BOOKS:

1. Piping design handbook: Macetta. John, M dekar1992
2. Pipeline & risers : Young Boi ,Elsevier Ocean Engineering Book series 2001Volume 3
3. Pipe Line Corrosion, Cathodic Protection: Parker M E and Peattie E G , Elsevier USA 2001

PRACTICALS

PCP401 Process Dynamics & Control Lab.

List of Experiment

1. To determine the time constant of a given thermometer and thermocouple
2. To study the open loop, three mode PID and two mode PD control
3. To study the working principal and calibration procedure of capacitance type level transmitter.
4. To obtain the step response of a single tank liquid level system to a step change in input flow and compare it with the theoretical response.
5. To study the inherent characteristics of control valve.
6. To study the theoretical time constant and damping coefficient of the manometer.
7. To study the interacting and non-interacting mode of system.
8. To study the behavior of a PID controller.

PCD411 Project Part- I

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B. TECH. VIII SEMESTER

Option A

HUL204 Innovation & Entrepreneurship

PCL407 Physico Chemical Treatment

Introduction to Water Pollution and Control: Environmental act and standard, Physical and chemical water quality parameter, Biological water quality parameter.

Pre-treatment & Physical treatment: Flow equalization & Aeration, Coagulation and Flocculation, Setting and Sedimentation & Settling Chamber Design, Filtration & Filtration System Design.

Wastewater treatment by Adsorption & Ion Exchange: Basics of the adsorption process, types of adsorbents used in practical applications, characteristics and general requirements of adsorbents, parameters for comparing different adsorbents during water treatment. the factors controlling the adsorption process, adsorption kinetics, basic equations of Pseudo-first-order and Pseudo-second-order kinetic models, and how to acquire data for kinetic analysis, fundamental concepts, mechanism and kinetics of ion exchange with strong cation exchange, and weak cation exchange reactions. different multiple ion exchange columns for water treatment, ion exchange practice resin selection, backwashing estimation of resin volume, regeneration, slow rinse, and cycle time.

Wastewater treatment by Membrane Based Technologies: Membrane, membrane process classification, general characteristics of membrane processes, and advantages & disadvantages of membrane technologies. the theory of membrane filtration, models of membrane filtration, the theory of membrane filter hydraulics, and the effect of temperature and pressure on membrane filtration. membrane materials and configurations, a comparison of different membrane configurations, membrane fouling, and its control, and membrane chemical cleaning or cleaning-in-place.

Advanced Oxidation Processes: Fenton and catalytic treatment, Photo-induced processes, Sono- and Electro-Chemical Treatment, Sono-hybrid wastewater treatment. Disinfection.

Case studies on wastewater treatment in various process, chemical and allied industries. Sugar industries, distillery, fertilizer industries, petroleum refining industries

Books

1. Lawrence K Wang Physico chemical treatment processes Humana Press

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B. TECH. VIII SEMESTER

PCL408 Waste to energy

Introduction, characterization of wastes. Definition of wastes and their classification • Important quality parameters of different types of wastes • Wastes suitable for energy production • Solid wastes and their classification • Waste water and their classification • Availability of agro based, forest, industrial and municipal solid wastes in India, vis-a-vis world • Availability of waste water in India, vis-a-vis world • Routes for solid wastes management

Energy production form wastes through incineration, energy production through gasification of wastes. Energy production through pyrolysis and gasification of wastes, syngas utilization. Properties of bio oil and need of its upgradation • Catalytic pyrolysis • Pyrolysis reactors • Utilization of pyro char and gases

Densification of solids, efficiency improvement of power plant, Plastics, their classification and code for recyclable plastics • Plastic types, their monomers and suitability for energy production • Plastic wastes generation and its need for proper management • Options for management of plastic wastes and recycling through pyrolysis • Pyrolysis reaction mechanism • Pyrolysis process types and their variables • Catalytic pyrolysis • Common steps for converting waste plastics to fuels

Energy production: Energy production form wastes Plastic, gas cleanup, energy production from organic wastes through anaerobic digestion and fermentation, introduction to introduction to microbial fuel cells. Energy production from wastes through fermentation and transesterification.

Cultivation of algal biomass from wastewater and energy production from algae. Reactor systems for cultivation/growth of microalgae • Harvesting of algal biomass • Treatment of waste water.

Books

Naomi B. Klinghoffer and Marco J. Castaldi Waste to energy conversion technology

PCD412 Project Part- 2



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B. TECH. VIII SEMESTER

Option B

HUL205- EQUIVALENT MOOC OF Innovation & Entrepreneurship

PED 413- INTERNSHIP

(A) Duration

- The duration of internship should be between 16 to 24 weeks.
- The external mentor should ensure that the attendance record of the student is maintained daily and the record along with total number of permitted/ unpermitted leaves be handed to the department at the end of approved internship duration.

(B) Nature of Internship

- Guiding principle behind internship would be improvement in knowledge/skills and employability of the students and emphasis would be on core companies and practical work on any project.
- Students would be allowed internships in research institutes if they indicate profound interest in academics/research.
- For non-core companies, the department would frame a policy by constituting a department level committee. For each student choosing to go to such an organization, the department level committee would review each case on its merit after receiving the justification from the student.
- The special opportunity for whole semester internship is optional, subject to the student getting a suitable and justifiable project work to replace the course work and project in the college. The permission shall be granted only on merit of the problem statement and the proposed organisation, not for general training similar to mandatory summer training after third year, in which information on some aspects may be provided without a well-defined project objective.

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Open Elective Courses

PEL209 Unit Operation in Industries

Crystallization Objectives, crystal lattice, types of crystal, crystal form, size and habit, formation of crystals, super saturation theory, factors affecting crystallization process and crystal growth. Study of various types of crystallizers including Swenson walker, tanks, agitated & batch, circulating magma, vacuum and crystal crystallizer etc. Methods for prevention of caking of crystals. Brief study of spherical crystallization process. Numerical problems on crystal yield.

Evaporation- Basic concept of phase equilibria, factors affecting evaporation, heat transfer in evaporators, Duhring's Rule and Raoult's law evaporators including natural circulation, forced circulation & film Type of evaporators and their applications single and multiple effect evaporators, operation of forward– backward and mixed feed operations,

Distillation: Distillation: Raoult's law and its limitation, Henry's Law, Phase diagram, volatility & relative volatility, General parts of distillator, simple steam and flash distillation, batch and continuous distillation, rectification distillation columns and their efficiency, McCabe Thiele method for calculation of number of theoretical plates, azeotropic, molecular & steam distillation, mathematical problems, applications in pharmacy

Drying: Utilities of Drying; thermal properties; Equilibrium moisture content (EMC); Drying theories; methods of drying, Contact drying, Convective drying, freeze drying, radiation drying,

Superheated steam, Drying rate period; types of dryers Deep bed, Flat bed, Continuous, Recirculating, LSU, Fluidized bed, Rotary, Tray, Tunnel and solar, etc.

Mixing Definition, objectives, mechanism and theory of mixing. Type of mixtures: liquid mixing, powder mixing, semi solids mixing. Principle, material of construction, applications, advantages and disadvantages of shaker mixer, propeller mixer, turbine mixer, paddle mixer, planetary mixer, double cone mixer, V mixer, sigma mixer and colloid mill, ultrasonic mixer, etc.

BOOKS:

1. Process Heat Transfer, Kern, D. Q. McGraw Hill USA
2. Unit Operation of chemical engineering, Mc Cabe, W.L. Smith, J C and Harriot, P., Mc Graw hill 1993
3. Mass transfer operation. Treybal, R.E. Kogakusha, McGraw Hill 1980.

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PEL312 Transportation of Petroleum Products

Transportation of petroleum & Petroleum products. Basics of pipeline construction, Operation and protection. Pump and compressor stations. Instrumentation and control. Metering and measurements of oil and gas. Tank-Trucks and Rail Transportation, Oceanic Tanker Transportation, Inland Water, Coastal and Oceanic, Tanker Size, Power, Cargo Space, Marine Storage Terminals, Shore Installation. Line Specifications, Plastic Pipes.

Traffic management, Fire and safety rules. Indian and Global supply scenario of petroleum and petroleum products. Product quality control and management.

Bulk distribution and handling-domestic, commercial and industrial. Storage of petroleum products in fixed installations Standards and regulations.

Role of International oil companies and OPEC pricing mechanism. Administered and market determined pricing mechanism in India.

Crude Oil and Product Flow Characteristics, Transportation of Cryogenic Liquids, Heat Flux Estimation, Temp Gradient in Flowing fluid in Exposed and Buried Pipeline, Insulation Types and thickness, Rheology and Non-Newtonian Behaviour, Stress and Pressure Drop Calculations. Flow Equation, Pressure Drop Calculations. Wey Mouth and Panhandle Equation, Design Factors. Pressure Drop in Non-Horizontal Pipeline. Stress Conditions in Pipeline and Analysis.

Conservation of petroleum & its products. Spot and other market control mechanism.

BOOKS:

1. Production and Transport of Oil and Gas, Szilas, A. P, Part B: Gathering and Transport, Development in Petroleum Series, 18 B, Elsevier, 1986,
2. Offshore Pipeline Design, Analysis and Methods, Mouselli, A. H. Pennwell Books, Tulsa, m Oklahoma.
3. Surface Production Operations, Arnold, Ken and Stewart, Maurice Volume I and II, Gulf Publishing Company, London.
4. Modeling of Oil Product and Gas Pipeline Transport, Lurie Mikhail, Wiley, 2008

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PEL313 Modern Separation Techniques

Basics of Separation Process:

Review of Conventional Processes, Recent advances in Separation Techniques based on size, surface properties, ionic properties and other special characteristics of substances. Process concept, Theory and Equipment used in cross flow Filtration, cross flow Electro Filtration, Surface based solid – liquid separations involving a second liquid.

Membrane Separations:

Types and choice of Membranes, Plate and Frame, tubular, spiral wound and hollow fiber Membrane Reactors and their relative merits, commercial.

Pilot Plant and Laboratory Membrane permeators involving Dialysis, Reverse Osmosis, Nanofiltration, Ultra filtration and Micro filtration, Ceramic- Hybrid process and Biological Membranes.

Separation by Adsorption:

Types and choice of Adsorbents, Adsorption Techniques, Dehumidification Techniques, Affinity. Chromatography and Immuno Chromatography, Recent Trends in Adsorption.

Inorganic Separations:

Controlling factors, Applications, Types of Equipment employed for Electrophoresis.

Dielectrophoresis, Ion Exchange Chromatography and Eletrodialysis, EDR, Bipolar Membranes.

Other Techniques:

Separation involving Lyophilisation, Pervaporation and Permeation Techniques for solids, liquids and gases, zone melting. Adductive Crystallization, other Separation Processes, Supercritical fluid Extraction, Oil spill Management, Industrial Effluent Treatment by Modern Techniques.

Text Book:

1. King, C. J., “Separation Processes”, Tata McGraw Hill, 1982.
2. Roussel, R. W., “Handbook of Separation Process Technology”, John Wiley, New York, 1987
3. Nakagawal, O. V., “Membrane Science and Technology” Marcel Dekkar, 1992

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PEL314 Hydrocarbon Engineering

Refinery Distillation Processes: Desalting, Process description of typical crude distillation, Fractional distillation, Vacuum distillation, Flooding, Weeping, Entrainment, setting of cut point, Crude assay analysis, ASTM, TBP, EFV, Distillation analysis curve calculation etc.

Fuel Refining and Lube Refining: Cracking, Coking, Reforming, Alkylation, Isomerization, Polymerization, and Sweetening etc. Solvent extraction, Dew axing, Propane deasphalting etc.

Hydro processing: Hydro cracking, Hydro treating, Hydro desulphurization

Oil and Gas separators: Principal of separation, Types of separators, their description. Various control and vessel internals, Oil and gas gravitational separator, Vertical two and three phase separator, Horizontal three phase separator etc.

Quality Monitoring of Petroleum Products : API gravity, Flash point, Fire point, Smoke point, Aniline point, Carbon residue, Kinetic viscosity, Pour point, Freezing point, octane number, Cetane number, Viscosity index, Diesel index, Calorific value, Burning test 24 hours, Characterization factor, Cloud Point, Vapour lock index, Carbon hydrogen ratio, Calculated ignition index, Carbon aromaticity index, U.O.P Characterization factor, Conrad son carbon residue, Water and sediment content.

Storage of Petroleum Products: Classification of inflammable liquids, Classification of storage tank, Floating roof tank, Fixed roof tank, Semi buried tank, Import/export loss, Breathing losses, Hazards and non-hazards area, and underground storage tank etc.

Marketing of Petroleum and Petroleum products: Role of International oil companies and OPEC pricing mechanism, Administered and market determined pricing mechanism in India

Natural gas: Structural analysis of gas industry, Types of natural gas, Units of natural gas, Impurities of natural gas, Natural gas quality, LNG Scenario in India etc.

Recommended Books

- 1 Nelson W. L., "Petroleum Refinery Engineering", Mc Graw Hill Book Co. ,(1985).
- 2 Watkins R. N., "Petroleum Refinery Distillation", Gulf Publishing Co.
- 3 Gary J. H., Handwork G. E., "Petroleum Refining Technology and Economics", Marcel Dekker, Inc., (2001).
- 4 Jones D. S. J., "Elements of Petroleum processing", John Wiley & Sons, (1995).
- 5 Waquier J. P., "Petroleum Refining" Vol. I & II , Technip, (1995)

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PEL315 Unconventional Energy Resources

CBM: Introduction & present status of coalbed methane- Global and Indian Scenario. Generation of coalbed methane gas & its properties, properties of coal as reservoir rock & accumulation. Geological and petrographic influences on coal, pore geometry, micropore, mesopore and macropore, cleat system

Thermodynamics of coalbed methane: Sorption – principles, sorption isotherms – types and interpretation. CO₂, CH₄ and N₂ adsorption – desorption, hysteresis, Langmuir isotherm, Swelling of coal matrix isotherm construction. CH₄ content determination in coal seams.

Overview of Drilling and Production systems of coalbed methane wells. Selection of Artificial lift for CBM wells. Hydro-fracturing of coal seams. Treating and disposing produced water. Testing of coalbed methane wells.

Gas Hydrate: Introduction & present status of gas hydrates. Formation, accumulation and properties of gas hydrates. Thermodynamics, kinetics and phase behaviour of gas hydrates. Types of gas hydrate. Exploration of gas hydrate. Drilling and production systems of gas hydrate wells. Prevention & control of gas hydrates. Gas extraction from gas hydrates. Uses and application of gas hydrates

Shale Gas / Oil: Global Scenario of shale gas/ oil production. Nature, origin and distribution of Shale Gas/ Oil. Characterization of Shale for Production of Shale Gas/ Oil. Extraction methods of Shale gas/ Oil: development of current practices. Location and size of production areas: estimated reserves and economics. Environmental issues in shale gas exploration. Markets and Global impact on energy scenario. Economic factor of shale gas/ oil production

BOOKS

1. Carrol John, Natural Gas Hydrates: A guide for engineers, Gulf Publications, 2003.
2. Farooqi Ali, S M, Jones S A and Meldau R F, Practical Heavy Oil Recovery, SPE, 1997
3. James T. Bart is, Frank Camm, David S. Ortiz, Producing liquid fuels from coal: Prospects and policy issues. NETL, DOE, USA, 2008, 198 p
4. A Guide to Coal Bed Methane Reservoir Engineering, Published by Gas Research Institute Chicago, Illinois USA.

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PEL 409 Introduction to Oil and Gas Engineering

Physical Properties of Reservoir Rock

Core analysis, conventional core analysis, conventional core analysis, Porosity, effective porosity, primary porosity, secondary porosity, porosity measurement, permeability, Effective permeability, fluid saturation, electrical resistivity, Darcy's law, Single and Multiphase flow etc.

Special Core Analysis

Wettability, capillary pressure characteristics, relative permeability, oil window etc. Flow of fluids through porous media: Darcy's law, single and multiphase flow. Reservoir flow through porous media, reservoir drive mechanism etc. Petroleum Exploration: Gravitational, Magnetic, Seismic, Electrical, Radioactive, Well logging methods etc.

Drilling

Introduction to on-shore and offshore drilling operations, onshore drilling techniques, cable tool drilling, rotary drilling, vertical drilling, Directional drilling, Horizontal drilling, Offshore drilling rigs, drilling accessories components, drilling fluid circulation system, functions of drilling fluids, Mud parameters.

Production

Production problems and work over operations, Well stimulation method, Hydraulic fracturing, matrix treatment, acidizing etc. Open Hole Logging: Electrical Surveys, Radioactive Surveys, Introduction to Well Logging: Mud logs, Pressure logs, Core logs, Wireline logs etc.

Recommended Books

- 1 Berger B. D., Anderson K. E., "Modern Petroleum" Penn well books.
- 2 Bradley H. B., "Petroleum Engineering Handbook", SPE.
- 3 Cole F. W., Reservoir Engineering manual.
- 4 Carl G., "Petroleum Engineering Drilling and Well Completions", Prentice Hall.
- 5 Mc Cray, Cole, "Oil Well Drilling Technology", Oklahoma Press

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